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SOME GEOGRAPHIC PROBLEMS INCIDENT TO THE GROWTH OF NEW YORK CITY*

By E. P. GOODRICH
Consulting Engineer

Among the items which a municipal engineer meets in his professional work and which are related to geography are the making of maps of different kinds such as those which show the streets, waterways, and railroads, and the distribution of population and of traffic, both present and prospec-

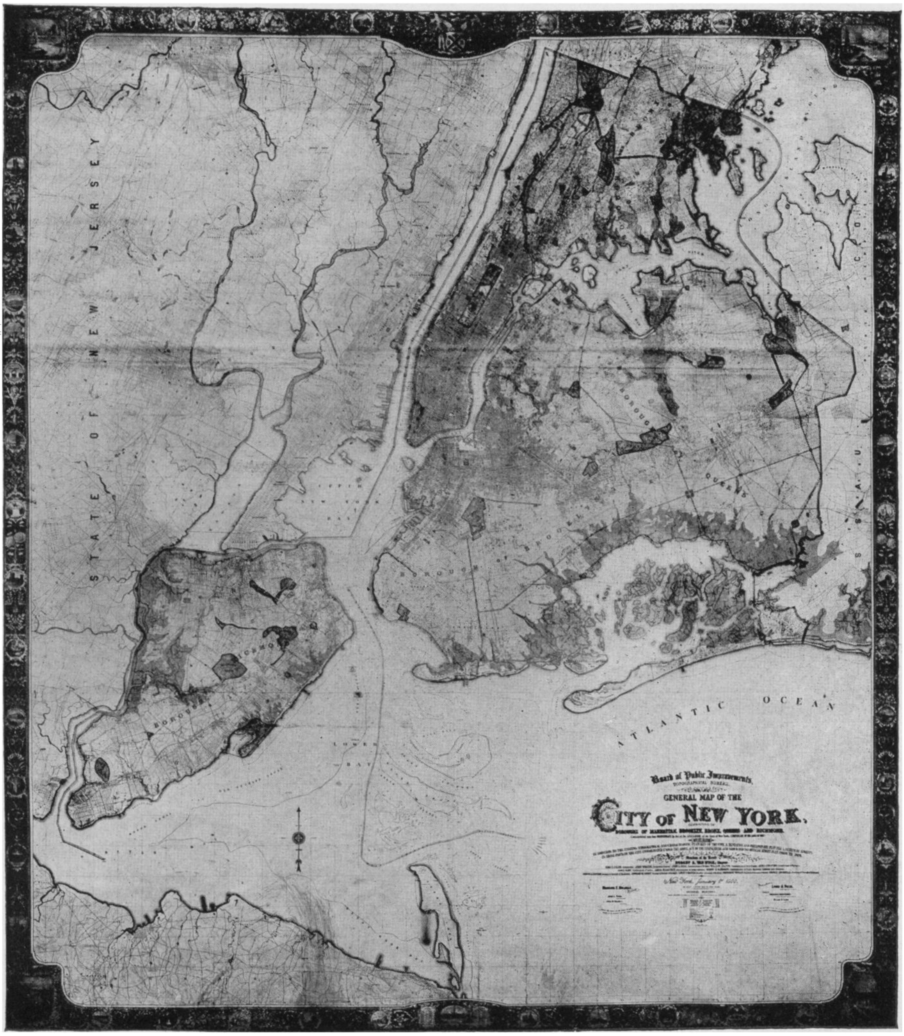

FIG. 1—Map of New York City prepared in 1900 for exhibition at the Paris Exposition. The scale of the original is 1,800 feet to 1 inch, or 1:21,600; there is also an edition on half the scale, 1:43,200. Its special value lies in its representation of relief (in contours) and the built-up area.

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* Read at the third joint meeting of the Association of American Geographers and the American Geographical Society, April 14 and 15, 1916.

tive; the computation of population data and related demographic phenomena and their reduction to diagrammatic form, such as population curves, past and future; the preparation of street railroad passenger diagrams, train operation diagrams, the water consumption curve, past and future, and traffic congestion diagrams; together with the collection and analysis of the data necessary to a proper study of each subject.

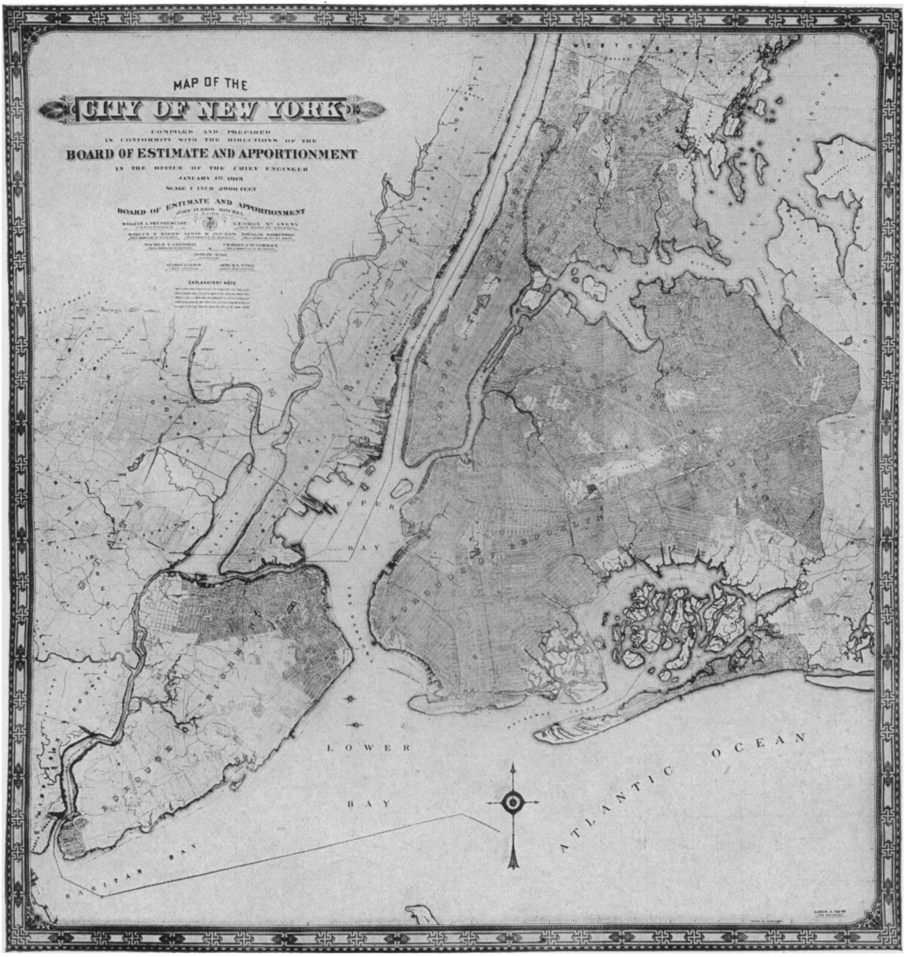
MAP OF THE
CITY OF NEW YORK
COMPILED AND PREPARED
IN CONFORMITY WITH THE DIRECTIONS OF THE
BOARD OF ESTIMATE AND APPORTIONMENT
IN THE OFFICE OF THE CHIEF ENGINEER
SCALE 1 INCH 2000 FEET
BOARD OF ESTIMATE AND APPORTIONMENT
JOHN PURROY MITCHEL
GEORGE McANENY
UPPER BAY
LOWER BAY
ATLANTIC OCEAN

FIG. 2—The official map of New York City published in 1915. The scale of the original is 2,000 feet to 1 inch, or 1:24,000. This map shows the theoretical street system. Only a relatively small proportion of the streets shown are physically open in most of the boroughs.

An interesting example of cartography is found in the 1900 map of New York City (Fig. 1) prepared by the Topographical Bureau of the Board of Public Improvements, Mr. Louis A. Risse, Chief Topographical Engineer, for exhibition at the Paris Exposition. Although it is marred by a more or less imaginary treatment of proposed streets and parks in the outlying dis-

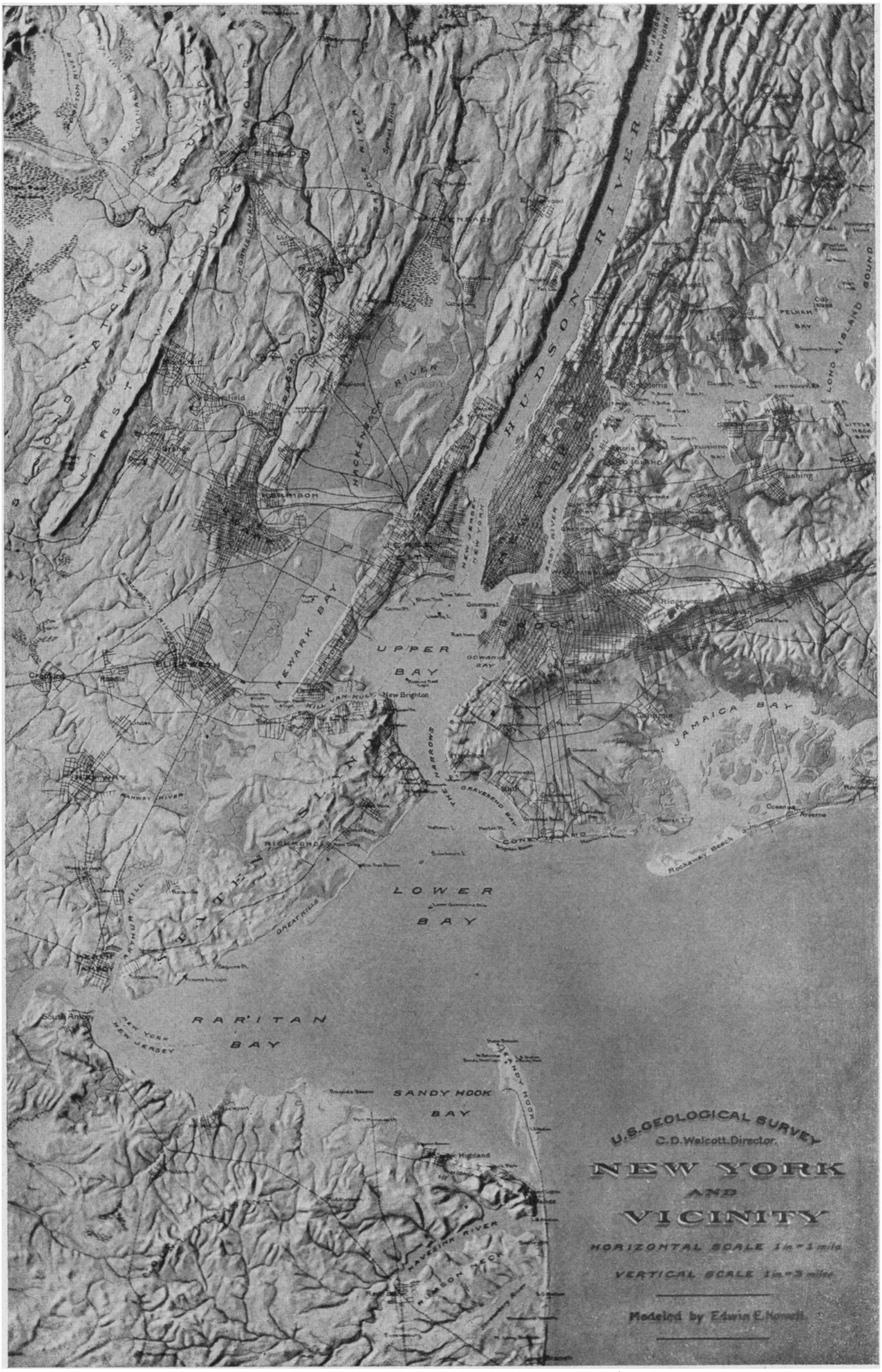

Fig. 3—Photograph of a relief model of New York City and vicinity. A study of this model in comparison with Figure 2 shows the present development in contradistinction to the theoretical street system. The model also shows how topographical features have guided and limited this development. (Courtesy of Howell's Microcosm.)

tricts, the map is of great value to the geographer because it represents relief (by contours) and the built-up area—elements rarely available on a city map and the latter generally only on detailed insurance atlases.

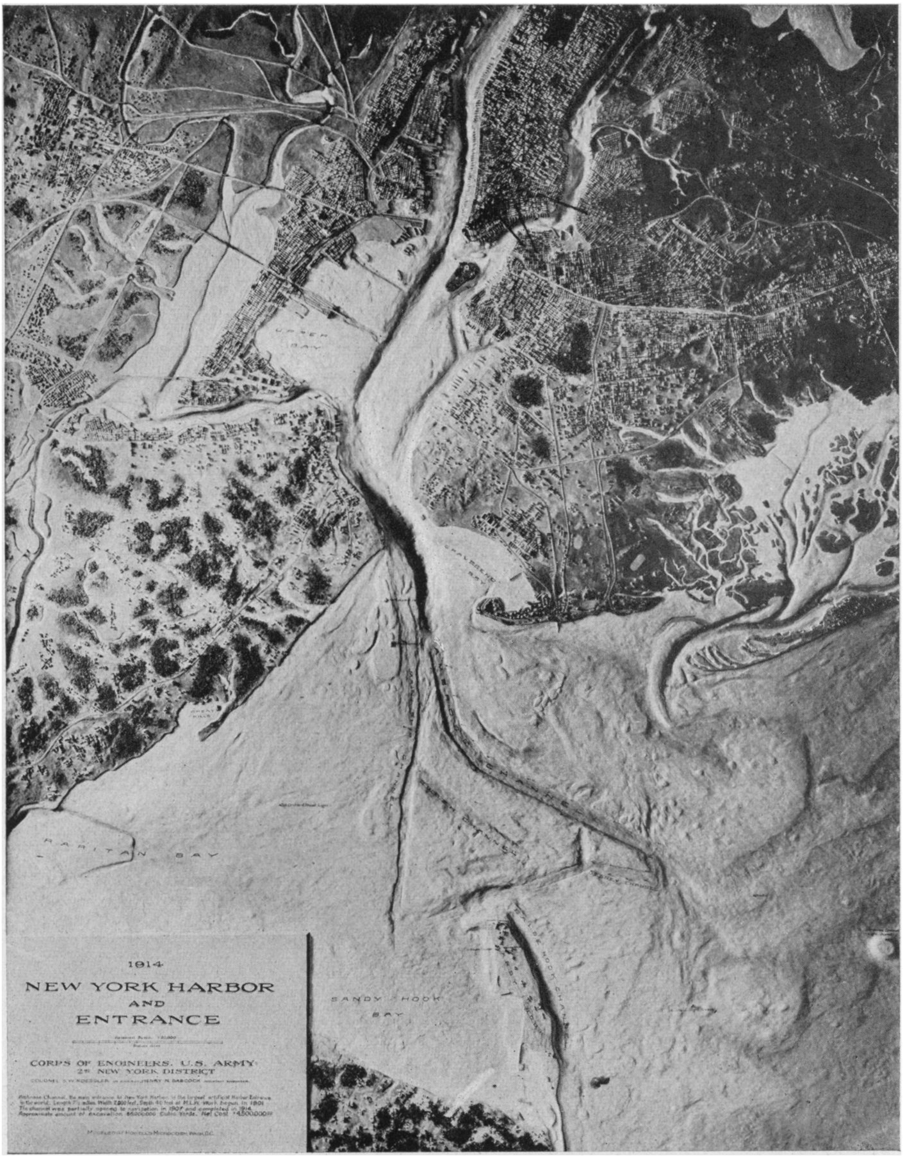

FIG. 4—Photograph of a relief model of the submarine topography of New York Harbor. It shows the artificial channels dredged to give entrance to New York Bay, and how and where the natural channels exist.

The 1915 map of New York City (Fig. 2), prepared by the Bureau of Public Works of the Board of Estimate and Apportionment, Mr. Nelson P.

Lewis, Chief Engineer, is a map which complies with the requirements of the City Charter in showing all streets whether actually paved, or only graded, or only staked out on the ground so lots can be sold, or only projected by the land owners and about which proper formalities have been complied with in the way of signing certain documents. In most of the outlying districts a traveler could negotiate the majority of the streets shown only on foot. The map was made after long and laborious triangulations and traverses, and a most carefully referenced system of co-ordinates has been established with monuments properly located in the field, all with an accuracy of at least 1 in 100,000.

A comparison of that map with a photograph of Howell's relief model (Fig. 3) will show at the same time the deficiencies inhering in a legal city map. On the model only those streets have been indicated which physically exist, together with a representation of the surface topography. A map of this kind is specially serviceable in studying problems of transportation, sewerage, population distribution, etc., because it shows in a comprehensive way the barriers to traffic and population growth, such as the ridges and valleys which alternate parallel with the Hudson River in the northern part of the city.

A model of a similar kind, which shows the underwater topography of New York Harbor (Fig. 4) is also of interest. It shows the submarine river channels, among other things, and also the effect which human effort has had in modifying natural causes in connection with the new direct artificial

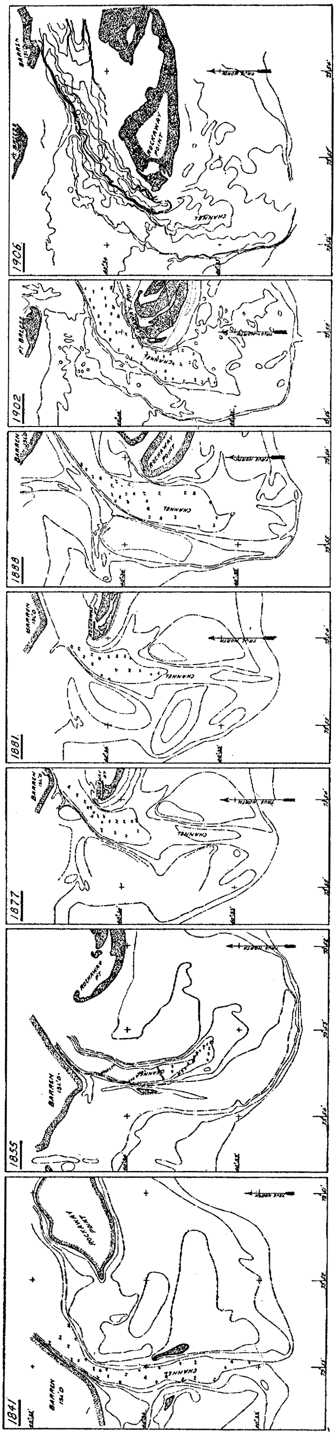

FIG. 5—Maps of the entrance to Jamaica Bay from 1841 to 1906, from "Report of the Jamaica Bay Improvement Commission," *House of Repr.*, *60th Congr.*, *2d Sess.*, *Doc. 1506*, Washington, 1909. A comparison of these maps, one with another, will show how the point at the entrance has moved progressively westward due to the drift of the beach sand.

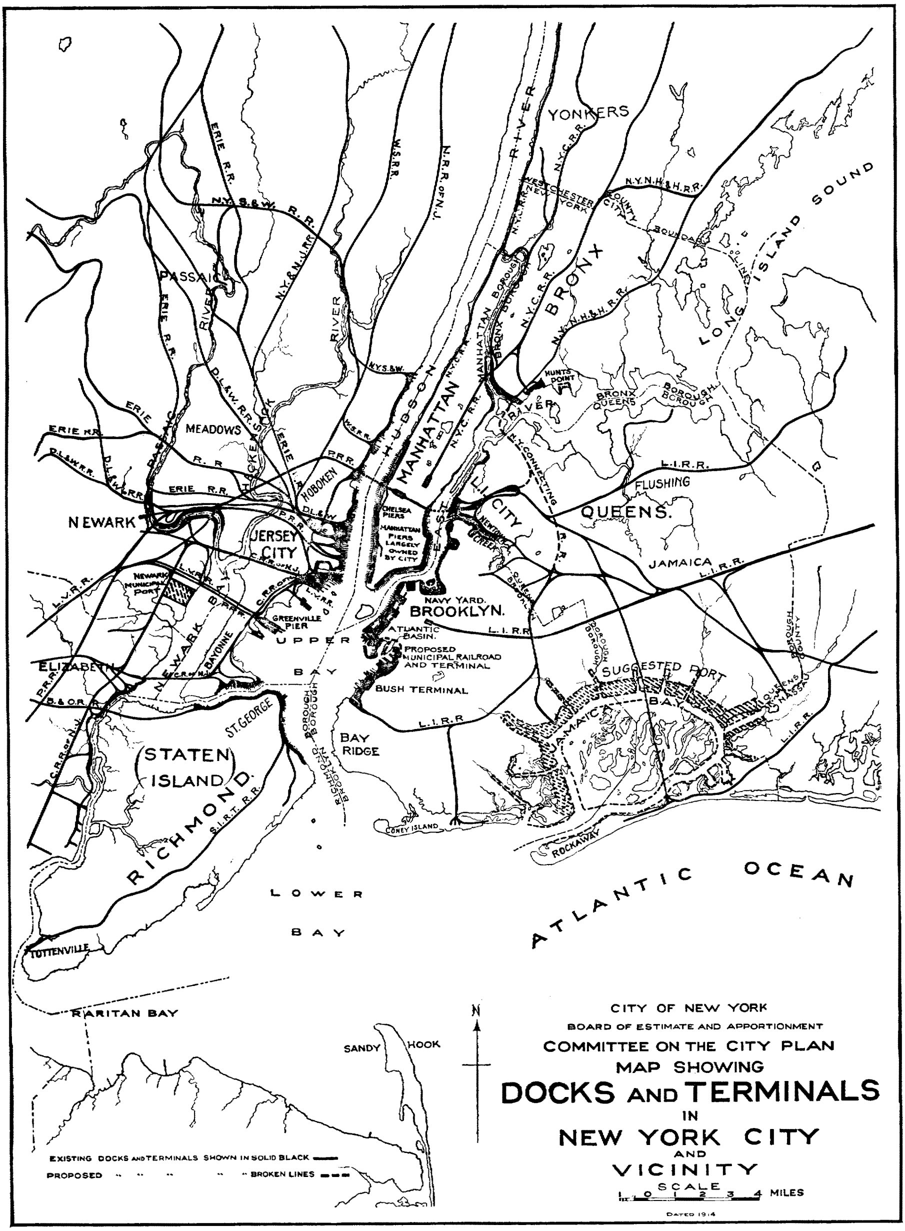

FIG. 6—Map showing existing and proposed docks and terminals in New York City. A comparison of this map with Figure 3 will indicate where it is impossible to develop more docks because of topographical limitations. (Courtesy of the Committee on the City Plan of the City of New York.)

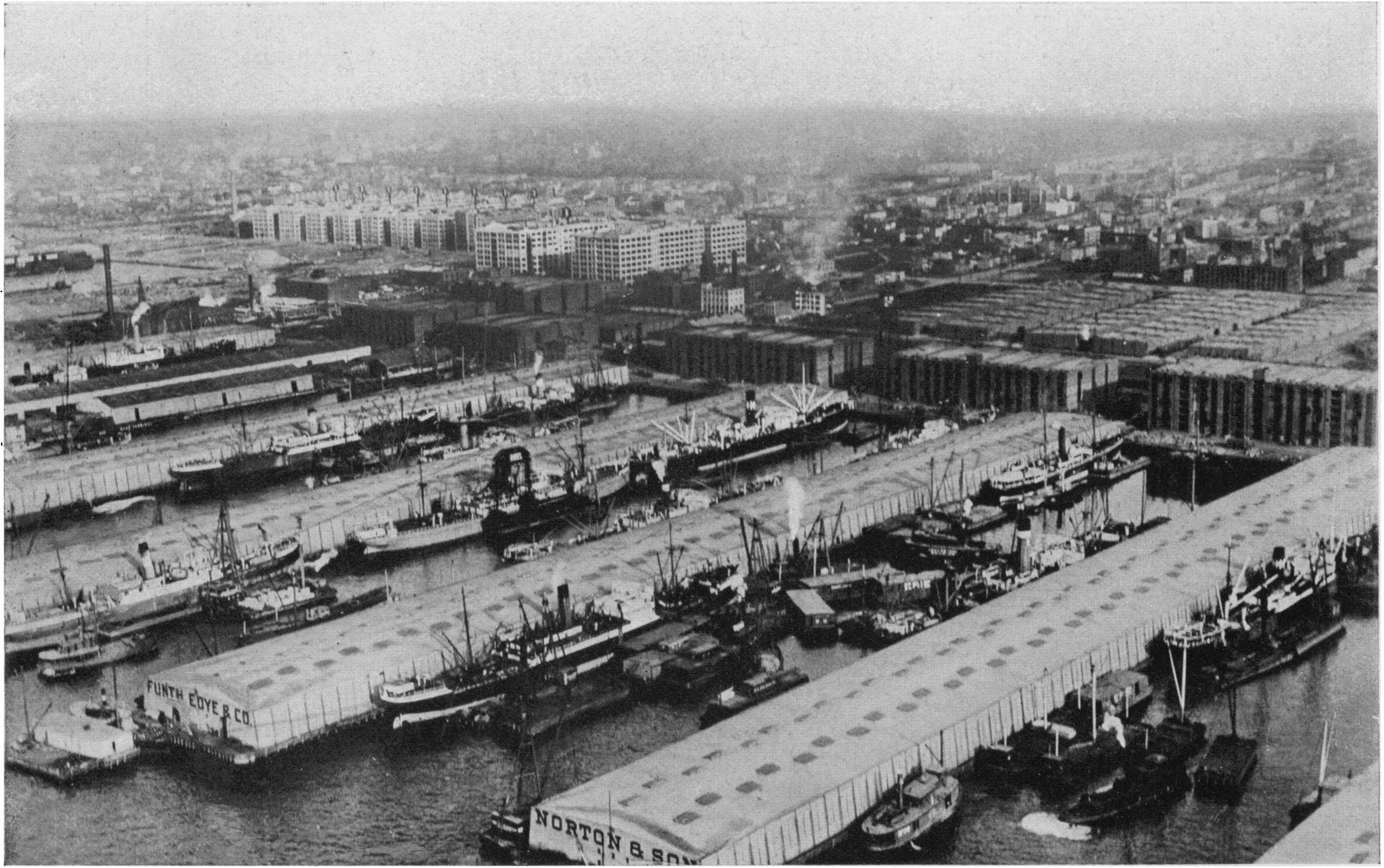

FIG. 7—Balloon photograph of the major portion of the Bush Terminal, Brooklyn (for location, see Fig. 6), showing the piers one-quarter of a mile long in the foreground, warehouses in the right background, and the tenant factory buildings in the left background. (Courtesy of the Bush Terminal Co.)

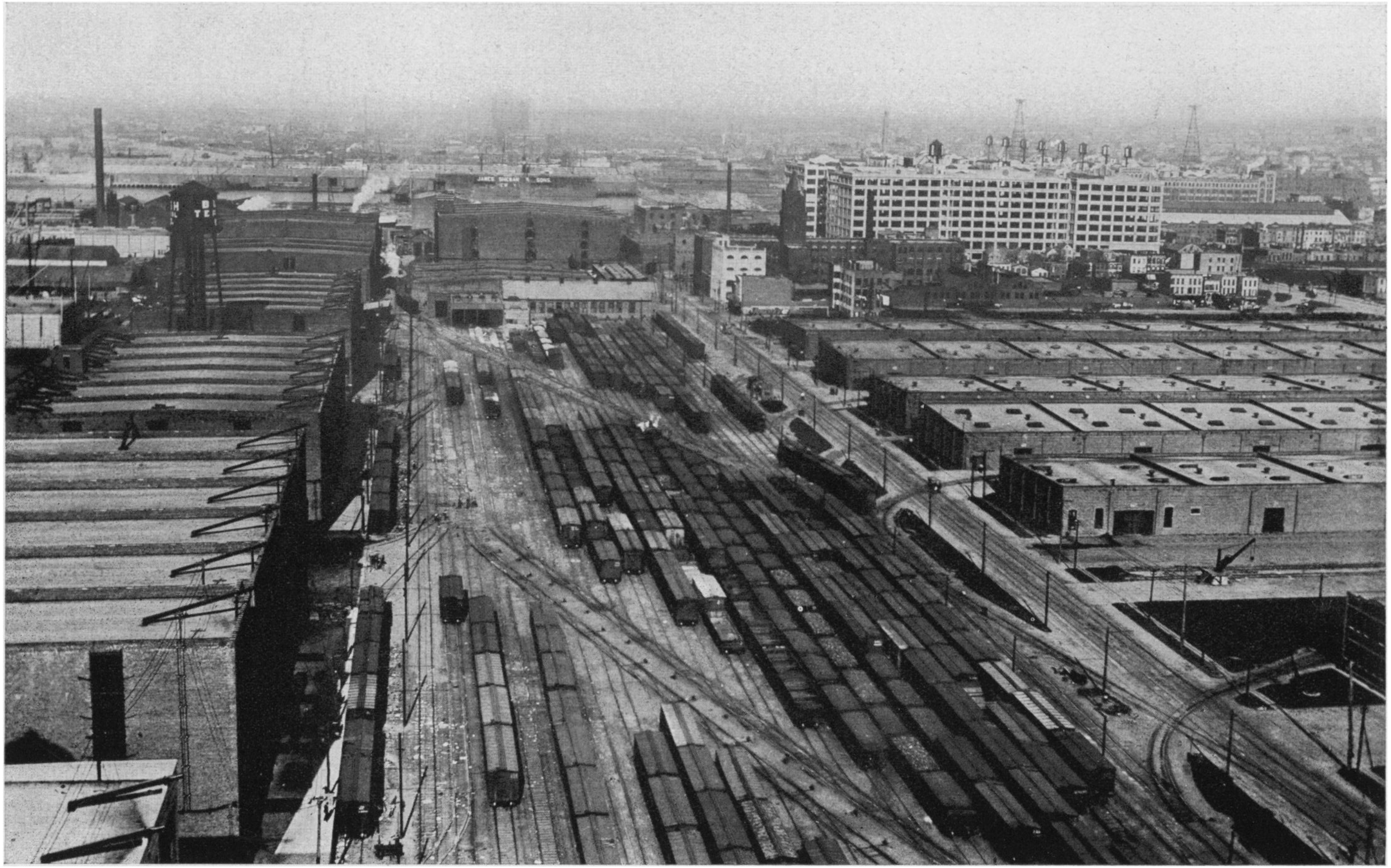

FIG. 8—Balloon photograph of a portion of the Bush Terminal showing the railroad yard in the center, concrete and brick multi-storied warehouses for miscellaneous merchandise on the left, one-storied warehouses for fibers (cotton, jute, sisal, etc.) in the right foreground, and the tenant factory buildings in the right background. (Courtesy of the Bush Terminal Co.)

channel between the inner harbor and the ocean. The fact that this artificial channel has apparently become self-sustaining will be watched with interest by harbor engineers and studied in connection with the phenomena of shore erosion and shift of channel which has evidently continued for centuries and which is now in process at the mouth of Jamaica Bay, for example (see Fig. 5).

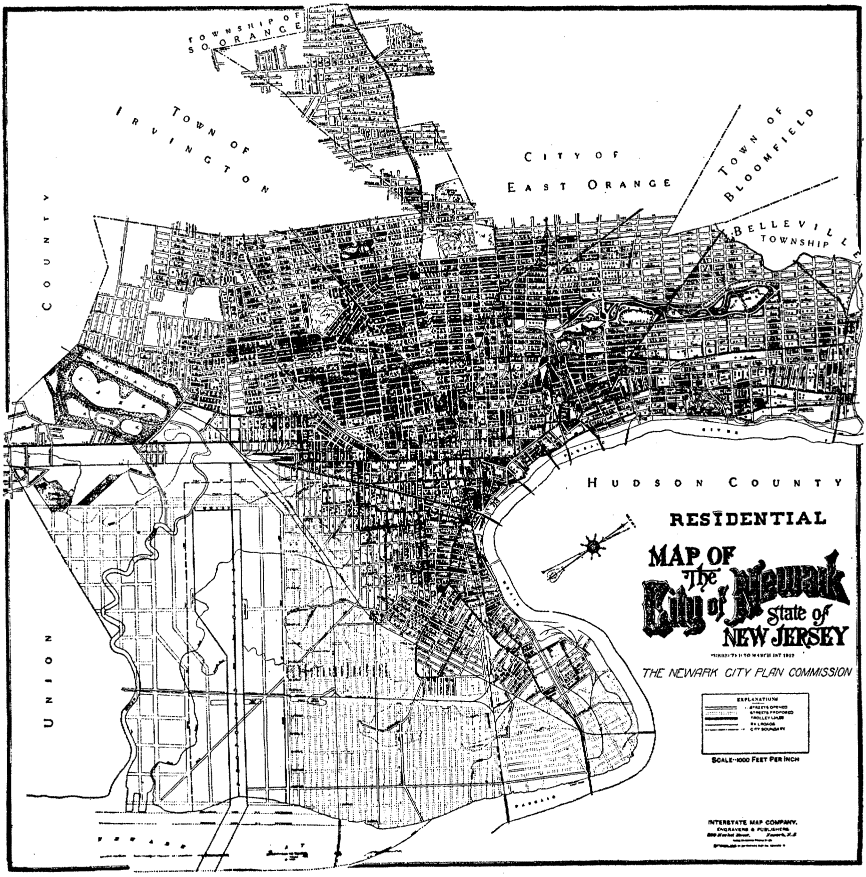

FIG. 9—Map of Newark, N. J., showing the distribution of population. The distribution of the residential population as given on the insurance maps is indicated graphically by dots. Each dot represents 25 people. The congested sections are shown very clearly by the density of the dots. Note the room for expansion to the north, south, and west, where dots are less numerous. (Courtesy of the Newark City Plan Commission.)

A harbor map which shows the present development (such as Fig. 6), when compared with a topographical relief map, indicates what a relatively small portion of New York City's waterfront has been actually and efficiently developed, and what a considerable extent is impossible of easy improvement for commercial use because of topographical features. There is in reality very small reason for the congestion which now exists on the west side of Manhattan Island, along the waterfront of the Hudson River. This phenomenon seems to be one caused rather by habit and sentiment than by the laws of economics.

Should this question of economics be carefully analyzed it would doubtless show how the Bush Terminal (Figs. 7 and 8) has been able to build up what has been considered by many as the most perfect waterfront terminal in the world. Such a study would take into consideration population distribution, distribution of manufactures, passenger transportation, street traffic facilities, etc. Studies of each of these varieties have been made, as illustrated upon the population and factory maps of Newark (Figs. 9 and 10), prepared by its City Plan Commission; the present and projected rapid-transit system map of New York (Fig. 11), the time-zone map of New York, which

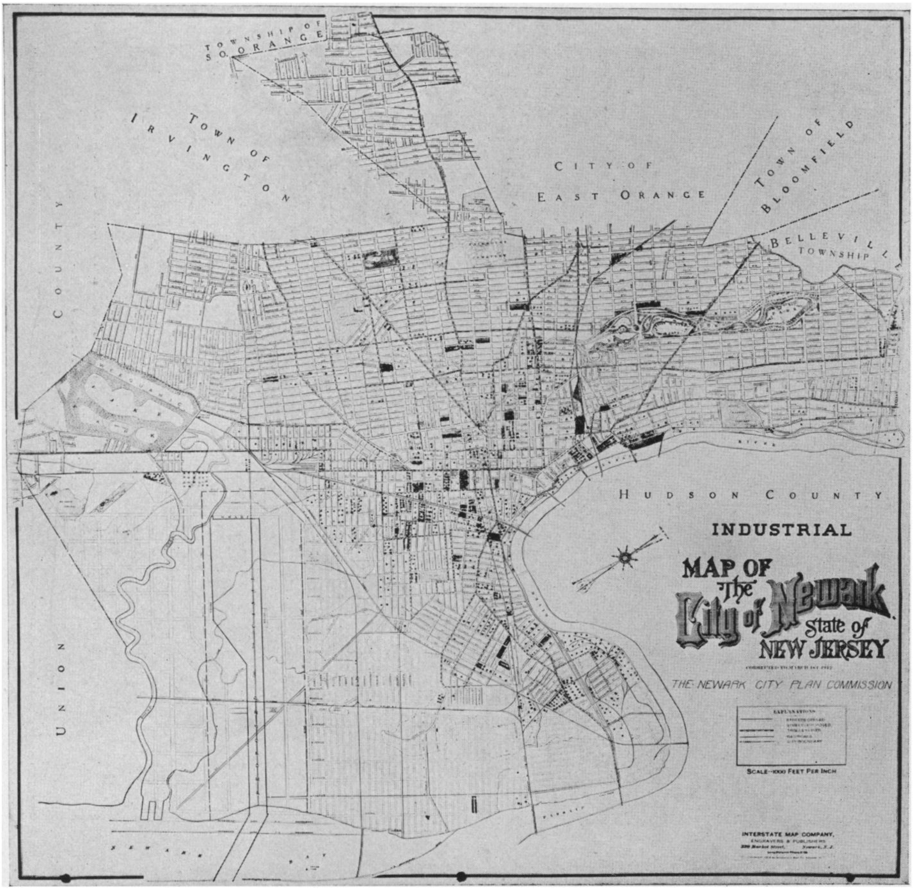

FIG. 10—Map of Newark, N. J., by the City Plan Commission, showing the location of factories and, by dots, the relative number of workers with their daily distribution. (Courtesy of the Newark City Plan Commission.)

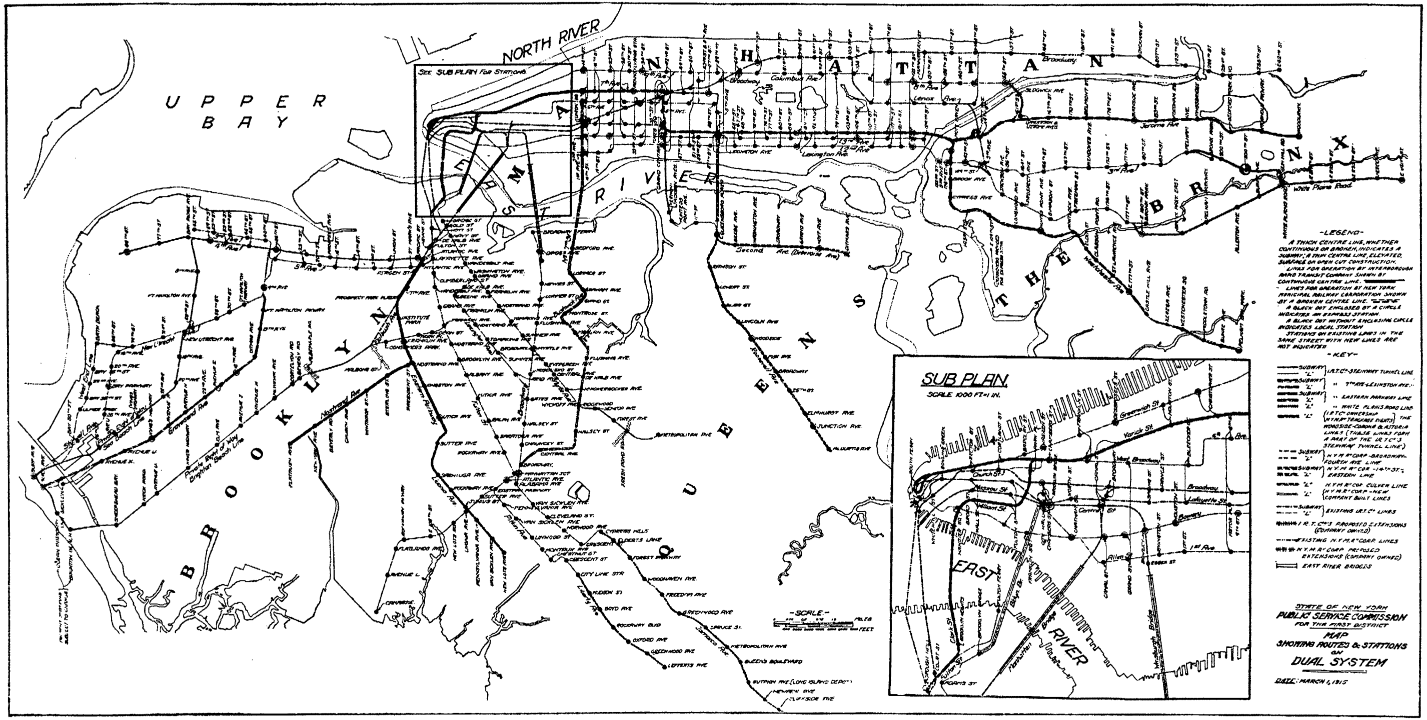
UPPER BAY
NORTH RIVER
SEE SUB PLAN FOR STATIONS
MANHATTAN
THE BRONX
EAST RIVER
QUEENS
BROOKLYN
SUB PLAN
SCALE 1000 FT=1 IN.
EAST RIVER
-SCALE-
-LEGEND-
A THICK CENTRE LINE, WHETHER CONTINUOUS OR BROKEN, INDICATES A SUBWAY; A THIN CENTRE LINE, ELEVATED, SURFACE OR OPEN CUT CONSTRUCTION.
LINES FOR OPERATION BY INTERBOROUGH RAPID TRANSIT COMPANY SHOWN BY CONTINUOUS CENTRE LINE.
LINES FOR OPERATION BY NEW YORK MUNICIPAL RAILWAY CORPORATION SHOWN BY A BROKEN CENTRE LINE.
A BLACK DOT ENCLOSED BY A CIRCLE INDICATES AN EXPRESS STATION.
A BLACK DOT WITHOUT ENCLOSING CIRCLE INDICATES LOCAL STATION
STATIONS ON EXISTING LINES IN THE SAME STREET WITH NEW LINES ARE NOT INDICATED
-KEY-
SUBWAY "L" I.R.T. Co. STEINWAY TUNNEL LINE
SUBWAY "L" " 7TH AVE-LEXINGTON AVE. "
SUBWAY "L" " EASTERN PARKWAY LINE
"L" " WHITE PLAINS ROAD LINE
"L" (I.R.T. Co. OWNERSHIP / N.Y.M. Ry. TRACKAGE RIGHTS) THE WOODSIDE-CORONA & ASTORIA LINES (THESE LINES FORM A PART OF THE I.R.T. Co.'S STEINWAY TUNNEL LINE)
SUBWAY "L" N.Y.M. Ry. CORP.-BROADWAY-FOURTH AVE. LINE
SUBWAY "L" N.Y.M. Ry. COR.-14TH ST.-EASTERN LINE
"L" N.Y.M. Ry. COR. CULVER LINE
"L" N.Y.M. Ry. CORP.-NEW COMPANY BUILT LINES
SUBWAY "L" EXISTING I.R.T. Co. LINES
I.R.T. Co.'S PROPOSED EXTENSIONS (COMPANY OWNED)
EXISTING N.Y.M. Ry. CORP. LINES
N.Y.M. Ry. CORP. PROPOSED EXTENSIONS (COMPANY OWNED)
EAST RIVER BRIDGES
STATE OF NEW YORK
PUBLIC SERVICE COMMISSION
FOR THE FIRST DISTRICT
MAP
SHOWING ROUTES & STATIONS
ON
DUAL SYSTEM
DATE: MARCH 1, 1915

FIG. 11—Map by the Public Service Commission showing routes and stations on the municipal rapid transit lines of New York City. The scale of the original is 1:28,000; of this reduction, 1:200,000. (Courtesy of the Public Service Commission for the First District.)

indicates the minimum time in which all points in the city within a five-cent fare limit can be reached by the rapid-transit system (exists only as a manuscript drawing and is too complicated to reproduce here); the trolley traffic distribution map of the city of Newark (Fig. 12), etc. The time-zone map was prepared by the City Plan Commission of New York City, which, in association with the Heights of Buildings Commission and the Commission on Building Districts and Restrictions (which three commissions are largely identical), has also studied the matters indicated by their names and are now presenting to the public and the authorities the results of their deliberations. The maps of Brooklyn indicating building-height limits (Fig. 13), limits of per cent of area which may be occupied by buildings (Fig. 14), and zones within which manufacturing and business and residences may be located (Fig. 15) are typical of those for the rest

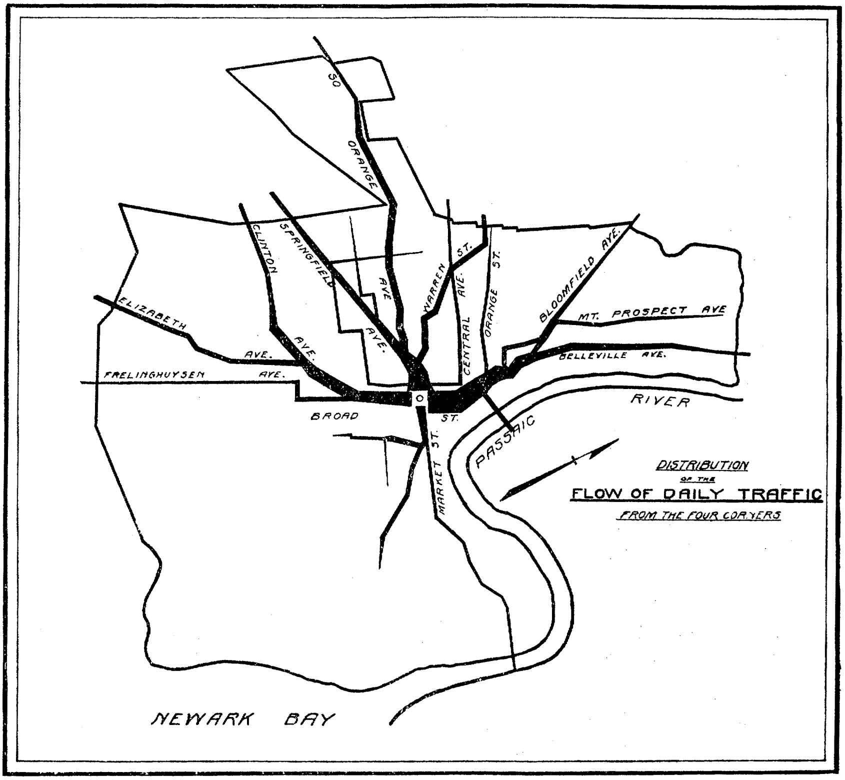

FIG. 12—A diagram representing the total number of passengers carried past various points in Newark, N.J., during a full day. Approximately 200,000 people enter and leave the "Four Corners" upon the trolley cars, each day, from 7 A.M. to 7 P.M. The greatest proportion of this travel is north and west as shown by the width of the bands in the diagram. These illustrate the proportion of travel upon each of the various routes. Note the great radial thoroughfares, the lack of cross-town lines, and the peculiar centralization at the "Four Corners." (Courtesy of the Newark City Plan Commission.)

of the city and, all taken together, if adopted[1], may so restrict population conditions as seriously to modify what may be called natural exigencies. Possibly housing congestion will be reduced, street traffic congestion controlled, street accidents minimized, real estate values stabilized, etc.

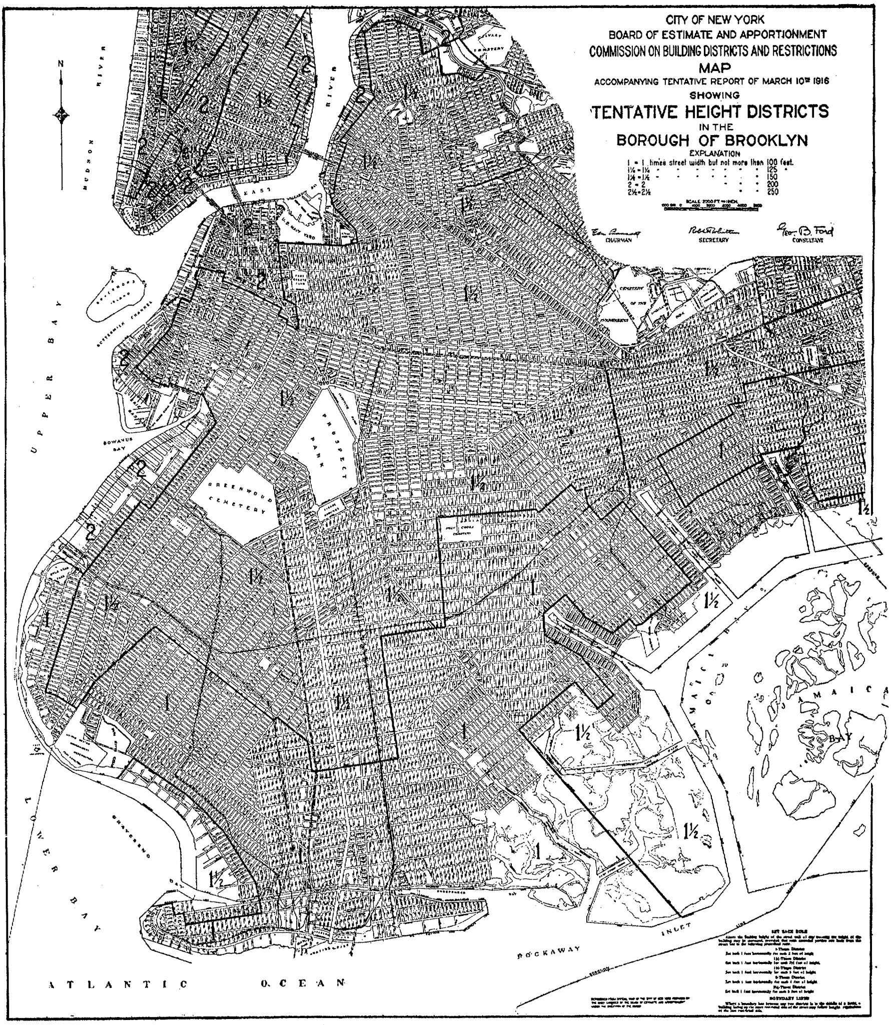

FIG. 13—A map of the Borough of Brooklyn showing proposed district of height-of-building restrictions. In the districts marked 1 buildings may be as high as the street is wide, but not more than 100 feet high; in the districts marked 1½ the height of buildings may be one and a half times the width of the street, but not more than 150 feet, etc. (Courtesy of the Commission on Building Districts and Restrictions.)

Closely related to maps are diagrams designed to represent combined geographical and other data. A "flow" diagram such as that of the "Four Corners" of Newark (Fig. 16) is fully as much a map as that of street traffic already mentioned. The facts revealed by this diagram led to the promulgation of a police traffic rule prohibiting all left-hand turns. This prohibition resulted in an increased speed of traffic over the street intersection much more than proportional to the number of vehicles eliminated.

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[1] Since this paper was read the zone maps have been legally adopted.

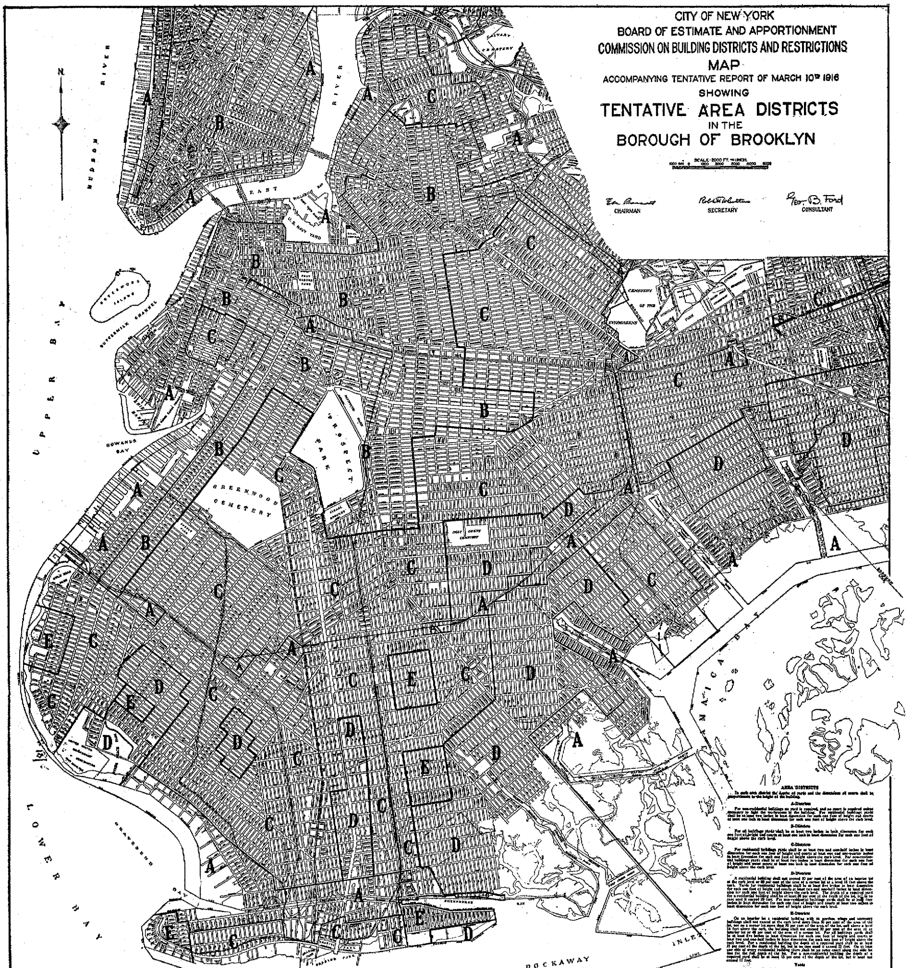

FIG. 14—A map of the Borough of Brooklyn showing proposed districts according to the proportion of the lot which may be occupied by the building on it. The area that may be covered by buildings decreases from the districts marked A, which are to be preserved mainly for business and manufacturing, to those marked E, which are to be kept for detached residences. (Courtesy of the Commission on Building Districts and Restrictions.)

The typical street-car riding diagrams of the same community (Figs. 17 and 18) visualize conditions along the full length of and at a designated spot on a certain street during each hour of the day, approximately, and are of material assistance in studying the daily movements of population. Another diagram of somewhat similar kind shows the loading of trains on one of the New York Elevated lines as they passed a given station (Fig. 19). This diagram was constructed to show the state of congestion on the road and whether or not it was possible to divert the passengers from another route on to the trains of that line. It may be of interest to note that no one of the trains was loaded to the limit which has been set by the Board of Health as the maximum number of persons which should be allowed in a trolley car.

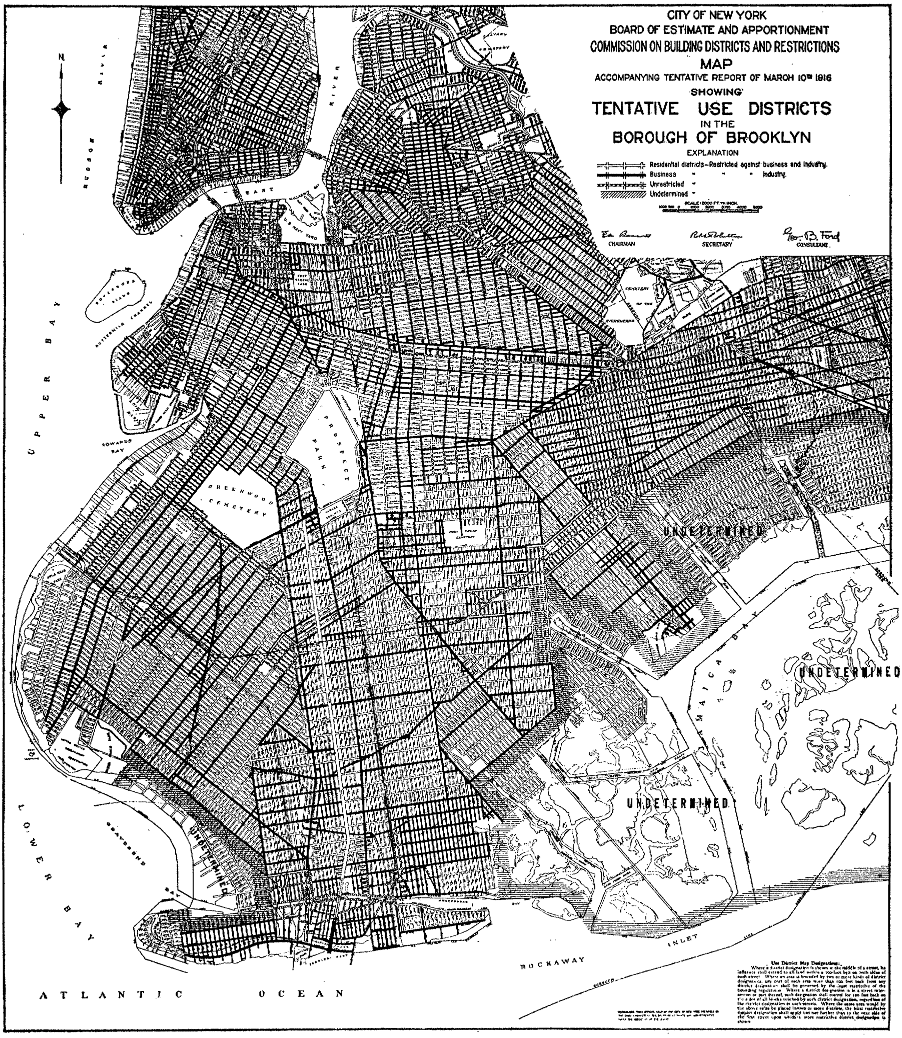

FIG. 15—A map of the Borough of Brooklyn showing proposed restrictions on the use to which the streets are to be put according to the buildings fronting on them. Streets marked with a double hair-line are to be residential and restricted against business and industry; streets in heavy black are business streets to be restricted against manufacturing; streets in mottled design are unrestricted. The hatched areas bordering Jamaica and Gravesend Bays are also unrestricted. (Courtesy of the Commission on Building Districts and Restrictions.)

Still another diagram showing pedestrian traffic conditions on Nassau Street in Manhattan (Fig. 20) has been used to determine the numerical figure for the number of persons using a sidewalk per foot of width, per minute, at which the walk may be considered as congested. The figure measuring the number of persons on each sidewalk during the fifteen-minute period just preceding the one in which the roadway was jammed so strikingly (i. e. 11.45 A. M. to 12 M., with about 800 persons on each sidewalk and about 425 pedestrians in the roadway) is believed to represent with fair accuracy what may be termed a condition of congestion.

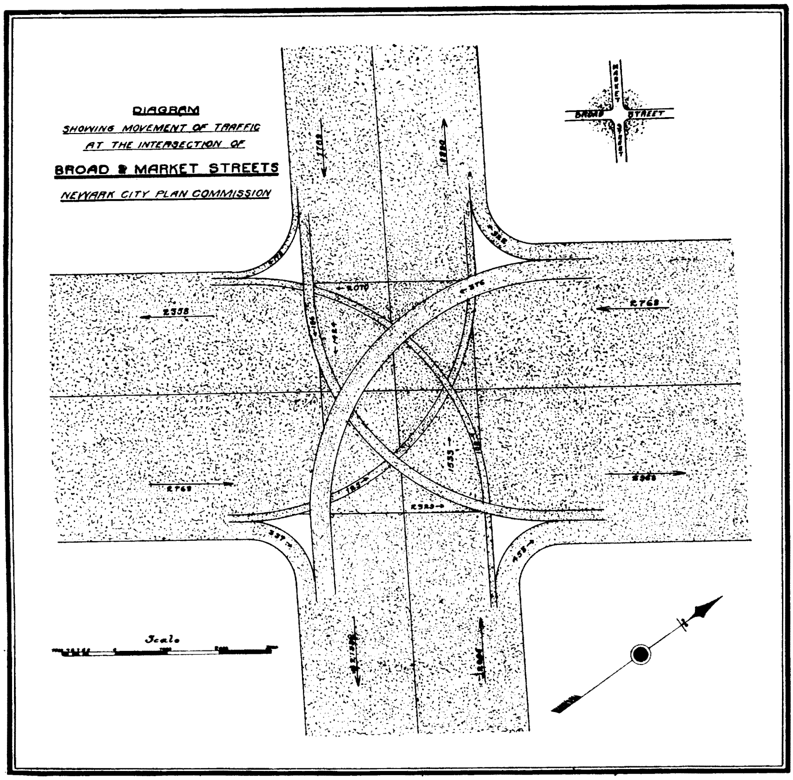

FIG. 16—A diagram showing the travel in each direction and on each turn at the principal intersection in Newark, N. J. The width of each band represents the proportion of travel in each of the various directions indicated by the arrows. The numbers show vehicles and cars which make this crossing each day, from 8 A.M. to 6 P.M. Note the small proportion of vehicles making left-hand turns. Since this study was made all left-hand turns have been prohibited at this point. (Courtesy of the Newark City Plan Commission.)

Some interest may also be found in the method used of ascertaining the average velocity of travel on Fifth Avenue across 34th Street by the device of identifying and numbering all the vehicles caught in a series of photographs taken every thirty seconds (see Figs. 21, 22, 23, and 24). The density is determined by averaging the total number of vehicles found in a block

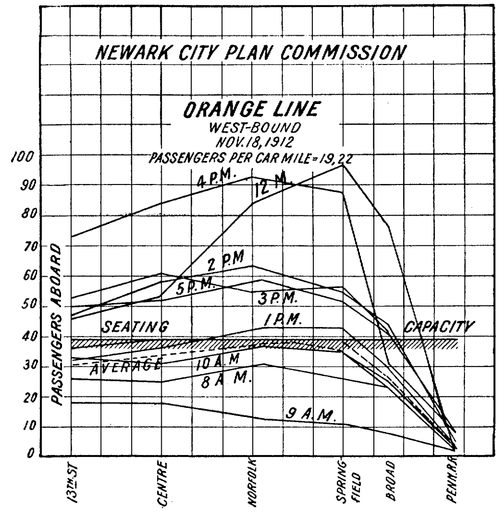

FIG. 17—A diagram showing the number of passengers on board a given car throughout a full typical trip, hour by hour, throughout the day of a Newark, N. J., street-car line. The number of passengers aboard at each point on the route is shown by the vertical scale. The hatched line represents the average seating capacity of each car. All curves above the seating capacity line represent standing passengers. Note the large number of standing passengers throughout very nearly the entire afternoon. This is one of the most congested lines in the city. Figures used in plotting this chart were obtained by men riding on the cars, a record of entering and leaving passengers being made at each stop.

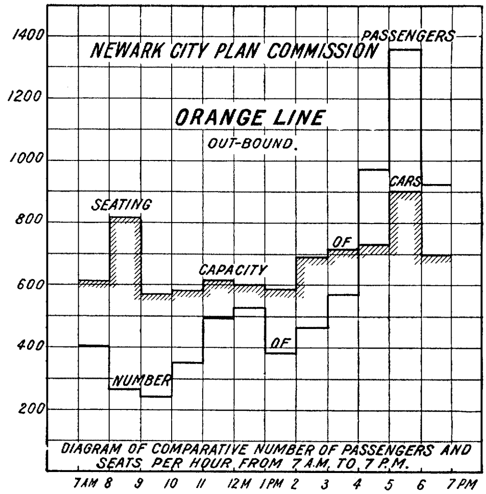

FIG. 18—A diagram illustrating supply and demand. The hatched line represents the total number of seats available each hour throughout the day, west-bound, on a Newark, N. J., street-car line. The full line represents the total number of passengers using this line, hour by hour, throughout the day. Note the excessive seat supply in the morning rush hour and the corresponding lack of seats in the evening rush hour. The irregularity of the flow of travel is well illustrated by the line of total passengers, and, by this, one can obtain a vague idea of the problem which faces the operating company in regulating the supply to meet the demand. Charts similar to this were made for each line operating in the city.

length in the several pictures. The total number passing is determined by the count. These two factors make a computation of the average velocity an easy matter.

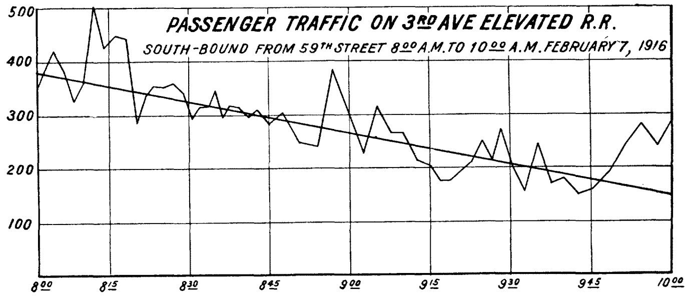

FIG. 19—A diagram showing the loading of trains on a New York Elevated line as they pass a given station. The figures on the left denote the number of passengers, those at the bottom the time from 8.00 to 10.00 A.M. Note the diminishing loading on every third train (approximately) and the diminishing loading as time passes during the morning rush hour.

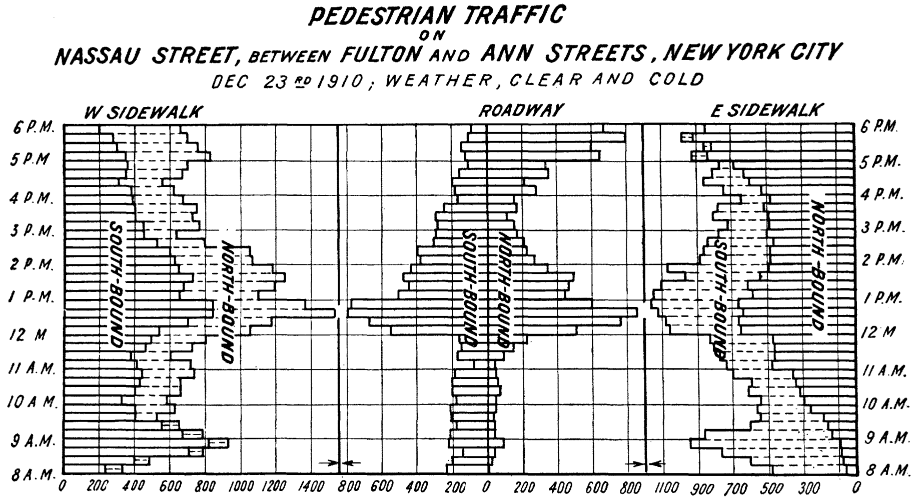

FIG. 20—A diagram showing the distribution of pedestrian traffic on Nassau Street, Borough of Manhattan, illustrating method of determining maximum convenient sidewalk traffic density. The figures at the bottom denote the number of pedestrians, there being a scale for each sidewalk and two for the roadway, increasing in the sense indicated by the arrow heads. The strips in the central section of the diagram indicate the overflow from the sidewalks. Note that at no time during business hours is the roadway free from pedestrians.

A natural line of inquiry growing out of street-traffic congestion studies is as to the future probabilities of the amount of street use. This query throws one instantly upon future population studies, in connection with which some diagrams of census statistics and their use in the realm of prophecy may be worthy of examination. The experience of Greater London (see Fig. 25) as to uniformity of growth would lead one to feel that he could prophesy

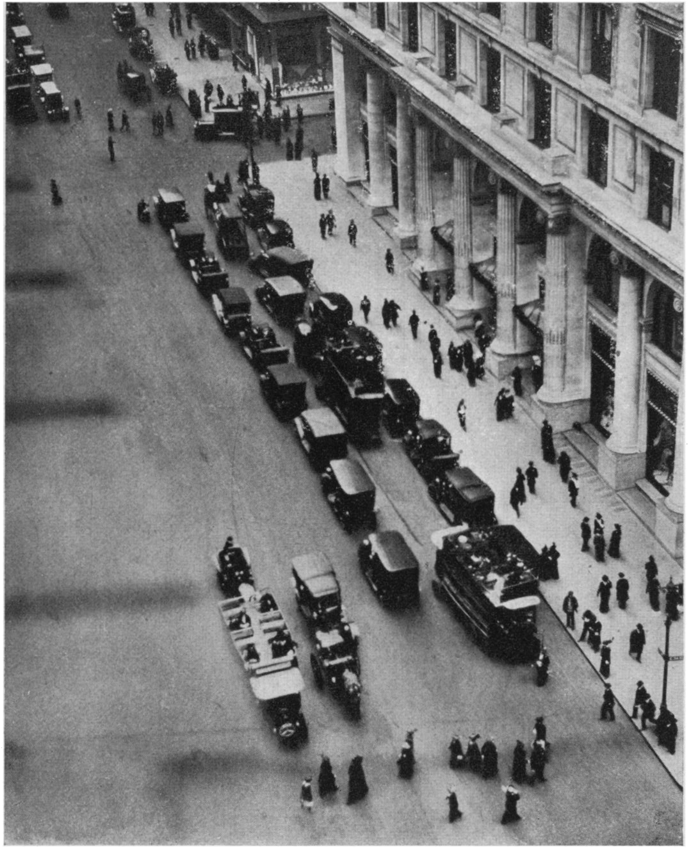

FIG. 21.

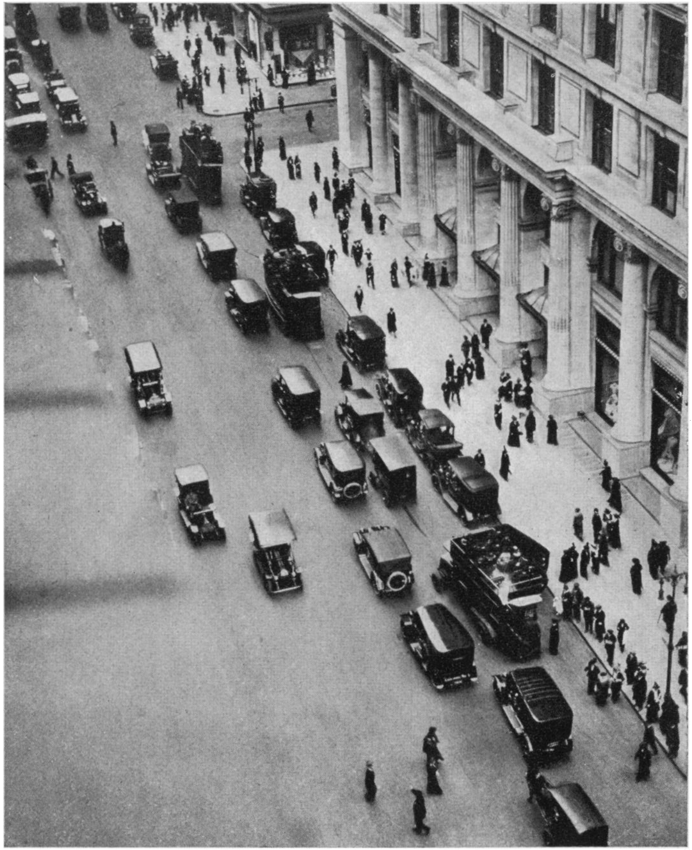

FIG. 22.

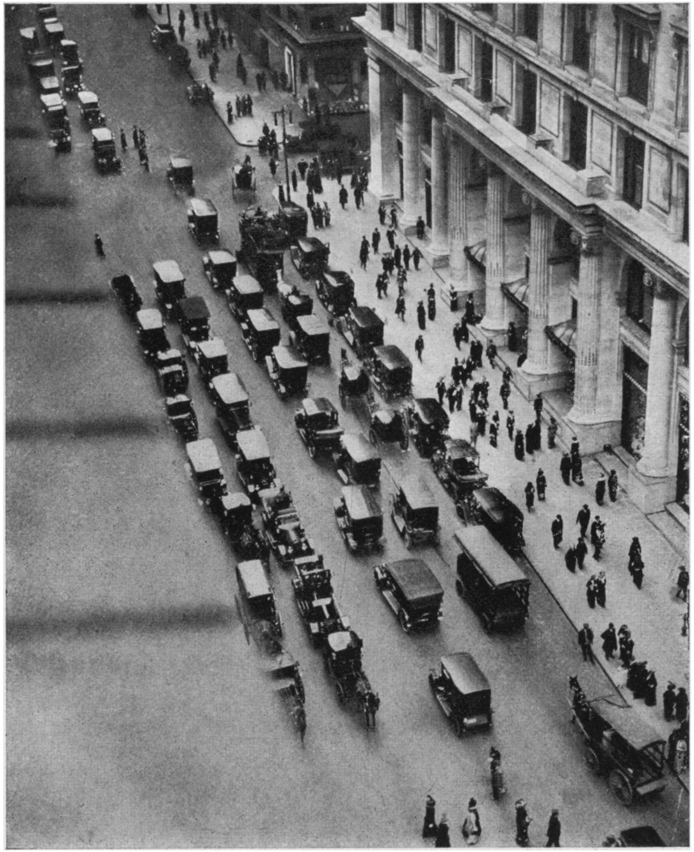

FIG. 23.

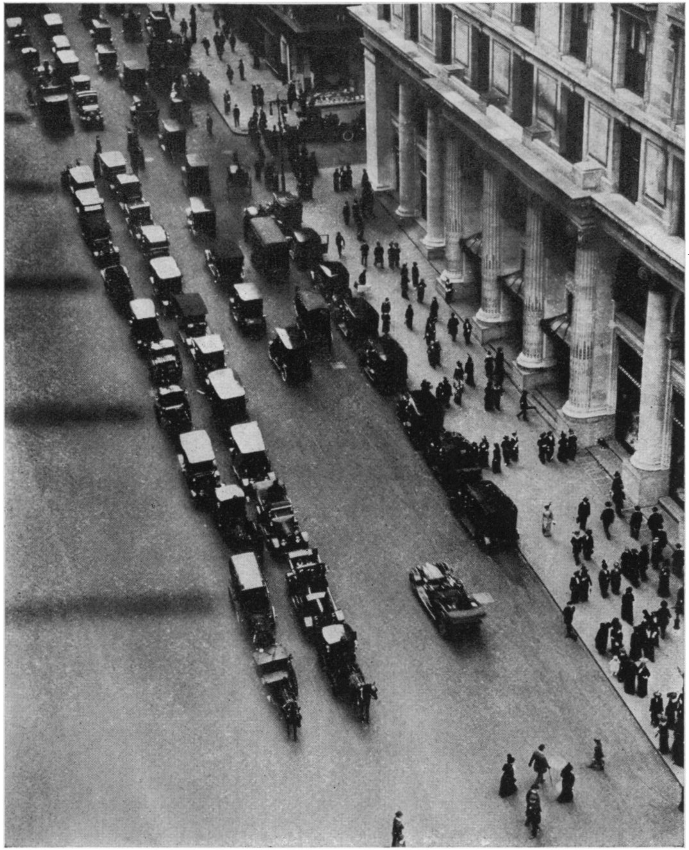

FIG. 24.

FIGS. 21-24—Four photographs, taken from the top of a building, of traffic on Fifth Avenue just north of 34th Street, Borough of Manhattan, showing vehicular traffic conditions and how it is possible to count the number of vehicles through a comparison of photographs taken thirty seconds apart, thus making possible estimates of vehicle density and average velocity. The photographs are in pairs, Figures 21 and 22 and Figures 23 and 24 belonging together. The same vehicles may be identified in each pair of photographs. Thus, the open automobile, the fifth of the inner row on the far side of the street in Figure 21, has progressed to the street-corner in Figure 22 during the thirty seconds elapsed, while the horse truck in the lower right-hand corner of Figure 23 has progressed four-fifths of the length of block, as shown in Figure 24.

with a fair degree of probability as to future censuses. Prophecy as to the future of New York City and especially of its smaller subdivisions is much more difficult. The estimates for the Borough of Manhattan (see Fig. 26) were based on a careful survey of all lands not now occupied with buildings and of the numbers of low buildings which may be replaced by higher ones so as to house more persons.

Intimately related to future population estimates are the corresponding ones as to the probable uses of telephones, of transit facilities, of the total consumption of water, etc. (Studies of this nature have been made by the telephone company, those who laid out the present rapid-transit system, etc.) A diagram prepared by the Bureau of Contract Supervision of the Board of Estimate and Apportionment of New York City (Fig. 27) illustrates a line of study employed to determine the latest date at which new sources of water supply must be provided to meet indicated needs.

This rapid survey will suggest, it is hoped, the frequent points of contact in the work of the geographer and the municipal engineer. Both often have recourse to the same methods, the one in recording and interpreting,

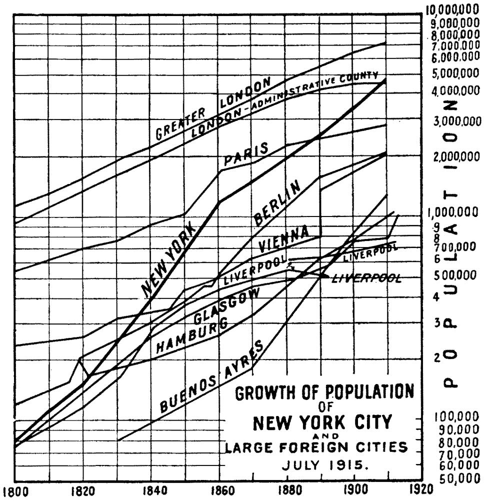

FIG. 25—A diagram of the growth of population of New York and large foreign cities. The relative uniformity of increase in many cases affords a fairly reliable basis for estimates of future population.

Figures 25 and 26 should be compared with the diagrams in Mark Jefferson's "How American Cities Grow," *Bull. Amer. Geogr. Soc.*, Vol. 47, 1915, pp. 19-37. The growth curves there, it should be borne in mind, however, often refer to the geographic and not the administrative city and are drawn on cross-section paper with co-ordinates of uniform intervals, while the present two diagrams are drawn with abscissas whose interval increasingly diminishes, a condition which tends to compress the growth curves.

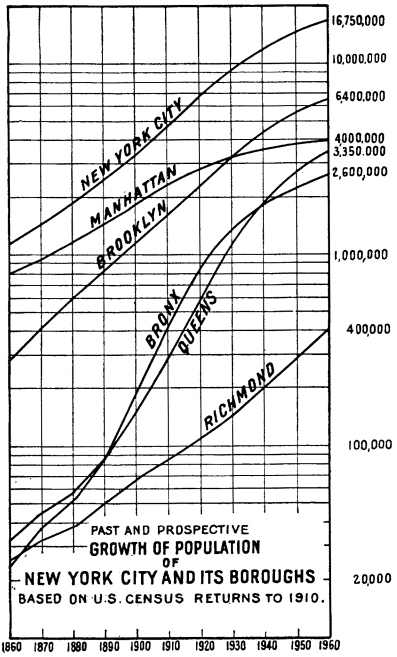

FIG. 26—A diagram of the growth of population of New York City and its boroughs since 1860, and estimates of future population to cover a century.

the other in guiding the development of that most complex and concentrated unit of human geography, the city.

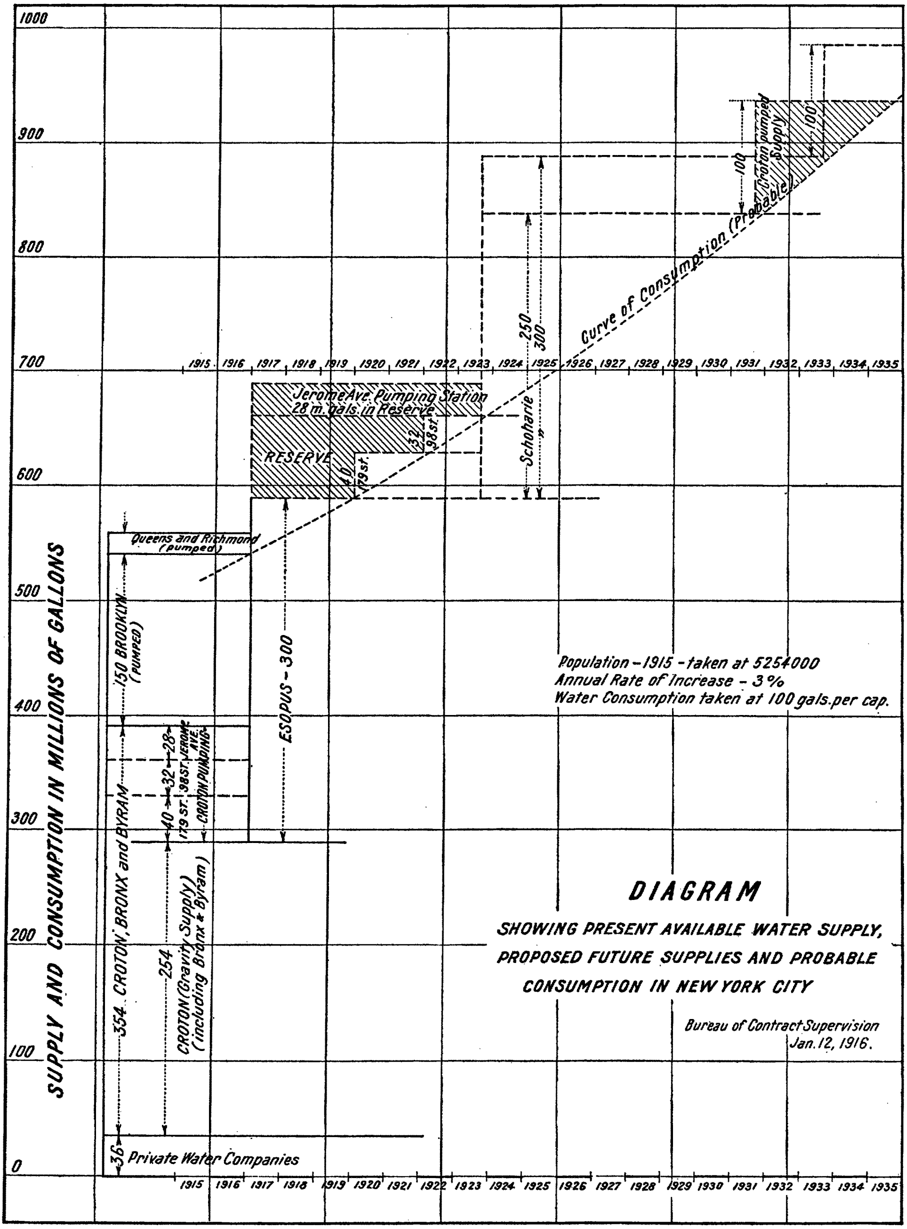

FIG. 27—A diagram showing the method of estimating future requirements for water supply based on probable curve of consumption and known sources of supply which can be made available from time to time. On the basis of this diagram estimates can be made as to the dates upon which a start must be made in developing new sources of supply, etc. (Copied from a diagram by the Bureau of Contract Supervision, Board of Estimate and Apportionment.)